# Unit 6 · Periodic Table

HARDER PRACTICE QUESTIONS

Full marks 41

Write your answers on separate paper. Show your working. Energies are in kJ/mol unless a question says otherwise. 1 eV per atom = 96.5 kJ/mol.

## 1 Spot the error [3]

Find the mistakes in the working and correct them.

Binita was asked for the configuration of the $Fe^{2+}$ ion (iron, Z = 26) and its unpaired electrons. She wrote:
"Fe is [Ar] $4s^2$ $3d^6$. The last electrons in were the 3d ones, so they come out first: $Fe^{2+}$ is **[Ar] $4s^2$ $3d^4$**. Four d electrons, one in each orbital, and the 4s pair: **4 unpaired**."

## 2 Whose fingerprints? [5]

These are the first four ionization potentials of three elements of period 3, with their names hidden.

| | 1st | 2nd | 3rd | 4th |
|---|---|---|---|---|
| X | 578 | 1,817 | 2,745 | 11,577 |
| Y | 496 | 4,562 | 6,910 | 9,543 |
| Z | 738 | 1,451 | 7,733 | 10,543 |

i. For each element, find how many times bigger the energy gets at its biggest jump.
ii. Name each element and give its valency.
iii. Write the formula of the chloride of each.
iv. Find the energy needed to turn 1.2 g of gaseous Z into ions with a charge of 2+. (Relative atomic mass of Z = 24)

## 3 Which explanation fits the evidence? [3]

In period 3, phosphorus has an ionization potential of 1,012 and sulphur, to its right, 1,000.
**Mijash:** "Sulphur's atom is bigger than phosphorus's, so its outer electron is farther out and easier to remove."
**Yasmin:** "Phosphorus has one electron in each 3p orbital. Sulphur's fourth 3p electron has to share an orbital with another, which repels it."
Use these covalent radii to decide: P 107 pm, S 105 pm. What does the result say about Hund's rule?

## 4 Three bottles [4]

Three bottles, A, B and C, have lost their labels. One holds potassium chloride solution, one potassium bromide and one potassium iodide; all three are colorless. Rajan has only chlorine water and bromine water, and some test tubes.

i. Describe how he can tell which bottle is which, using as few tests as he can.
ii. Write the equation of each reaction he would see.
iii. His friend suggests adding iodine solution to each bottle first. What would that show?

## 5 Pushing past the table [4]

All 118 elements known today fill the table to the end of period 7. Suppose element 119 is made.

i. Which shell and subshell would its last electron go into?
ii. Give its period, block and group.
iii. Predict its valency, and the formula of its oxide and of its chloride. (Call it M.)
iv. Predict whether its first ionization potential is above or below cesium's 376 kJ/mol, and how it would react with water, compared with cesium. Give a reason.

## 6 Which bond pulls hardest? [4]

On the Pauling scale, F = 3.98, O = 3.44, Cl = 3.16, N = 3.04, C = 2.55 and H = 2.20.

i. Find the difference in electronegativity for each of these bonds: C–H, N–H, O–H, H–Cl.
ii. Arrange them from the most evenly shared pair to the least.
iii. In which of them is the hydrogen end most positive?
iv. Which atom, of these, would make the bond with hydrogen even less evenly shared than any of the four? Give its difference.

## 7 Same number of electrons [3]

The ions $O^{2-}$, $F^{-}$, $Na^{+}$ and $Mg^{2+}$ all have 10 electrons, arranged 2, 8.

i. Arrange them from largest to smallest, without looking up any radius.
ii. Explain your order.
iii. Gaurav says, "$Na^{+}$ and $Mg^{2+}$ both lost electrons, so they must be the same size." Use the unit's radii, $Na^{+}$ 102 pm and $Mg^{2+}$ 72 pm, to show how much he is off, as a percentage of $Na^{+}$.

## 8 Correct the misconceptions [3]

The paragraph has three mistakes. Write each mistake and correct it.

> Sadikshya wrote: "Metals react by losing electrons, so as you go across period 3 from sodium to aluminium they get more reactive, because they have more electrons to lose. Chlorine has the highest electronegativity of all because it has the highest electron affinity. White phosphorus catches fire so easily in air because it is better at taking electrons than sulphur is."

## 9 Predict, then explain [4]

Write your prediction first, then explain it.

> Solutions of compounds of these ions stand on a shelf. Using only the ions' configurations, predict which compounds are colored and which are colorless or white: **$Sc^{3+}$**, **$V^{3+}$**, **$Mn^{2+}$**, **$Fe^{3+}$**, **$Ti^{4+}$**, **$Zn^{2+}$**. (Z: Sc 21, Ti 22, V 23, Mn 25, Fe 26, Zn 30)

## 10 Estimate it [3]

Hydrogen's ionization potential is 13.6 eV per atom.

i. Express it in kJ/mol.
ii. Roughly how long would a 1 kW heater have to run to supply the energy to ionize 1 mole of hydrogen atoms (1 g), if all of its energy went into that? (1 kW = 1 kJ each second)
iii. The atoms of cesium are much bigger than those of fluorine. About how many times bigger is a cesium atom in volume, if atoms are taken as spheres of the covalent radii 244 pm and 57 pm?

## 11 Think [3]

Chlorine releases 349 kJ/mol on gaining an electron, and sodium needs 496 kJ/mol to lose one. Sagar says, “So sodium atoms and chlorine atoms in the gas state should swap an electron and give out energy.”

i. Is he right? Show it with the numbers.

ii. Yet sodium burns in chlorine. What must he have left out? Say what happens after the ions form.

## 12 Make your own [2]

Write a “Which element am I?” puzzle of three clues about an element up to atomic number 30, using period, block, group, unpaired electrons or ionization potential. No two elements may fit all three clues. Give the answer and show that no other element fits.